AD-A033 242 DUMONT ELECTRON TUBES CLIFTON N J F/G 9/1

STUDY AND IMPROVEMENT OF THE S-1 PHOTOEMISSIVE SURFACE.(U)

APR 68 H TIMAN DA-44-009-AMC-1811(E)

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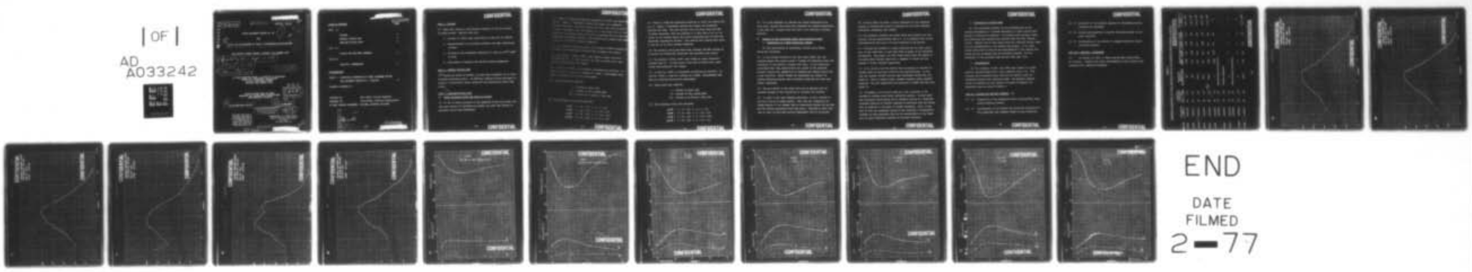

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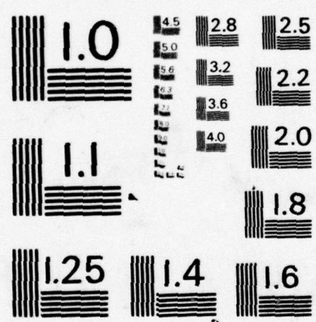


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

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(14) ETC-38-68

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# FIFTH QUARTERLY REPORT NO. 15 (1)

FOR

(6) STUDY AND IMPROVEMENT OF THE S-1 PHOTOEMISSIVE SURFACE. ~~(U)~~

THIS REPORT COVERS PERIOD 1 AUGUST - 31 OCTOBER 1967

(9) Quarterly (5th) rept. no. 15, 1 Aug-31 Oct 67,

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Approved for public release;
Distribution Unlimited

(10) Hans Timan

DU MONT ELECTRON TUBES, A DIVISION OF FAIRCHILD
CAMERA AND INSTRUMENT CORPORATION
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UNITED STATES ARMY ENGINEER
RESEARCH AND DEVELOPMENT LABORATORIES
FORT BELVOIR, VIRGINIA

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PREPARED BY: Hans Timan, Project Engineer

RELEASED BY: Alan Howell, Contract Administrator

DU MONT CONTROL DOCUMENTS: SI-6384, T6-2018, MO-10198



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[redacted]

PART I - PURPOSE

(C) Under this contract, photoelectric emission of the S-1 surface is being studied. Specific aims are:

1. Increase of white light sensitivity to 100 $\mu$a/l for 2870°K.

2. Reproducibility of processing schedules for high sensitivity cathodes.

3. Lowering of the thermionic emission to a value of $10^{-13}$ A/cm$^2$ or less.

4. Measurement of physical and optical surface properties.

PART I - GENERAL FACTUAL DATA

(C) During the month of October, 14 tubes were assembled, 10 of which attained processing status. In addition, numerous trials were made to produce a satisfactory "space reflector" and satisfactory heavy $TiO_2$ coats.

PART I - DETAILED FACTUAL DATA

A) Tubes processed during the month of October

(C) Of the 10 tubes processed on the pumpstand during this month, two were poor because of unsuitable Ag layers, two were lost because of generator bursts upon prewetting.

(C) Tube No. 0-285 was pretreated similarly to 0-256 (see Report #1 pg. 3). Again, a reasonable cathode was formed, but thermionic emission was high. The same behavior has also been found on 0-256. It seems, therefore, that the presence of a thin film of Bi (or its oxide) on the cathode before the actual processing does not show any thermionic suppression effects. Such effects have clearly been shown in the use of Bi after cathode formation.

(C) Two surfaces, which had heavy $TiO_2$ coatings (80-90% coverage of Ti metal) had "broken-up" substrates and processed very poorly.

(C) Two surfaces (0-281, 0-287) were formed as space reflective cathodes (Sp RC). In both cases Al was used as mirror and a very poorly reflecting Sp R was formed.

(C) In Tube No. 0-281, no reasonable processing was possible. In Tube No. 0-287, a very poor cathode was formed. Measurements were made to establish any possible enhancement.

(C) Three areas were compared:

I : Cathode on glass only
II : Cathode on $TiO_2$ coated glass
III : Cathode on Al mirror + $TiO_2$ coat

(C) The following ratios were measured:

4535Å : I : II : III = 1 : 1 : 1.5
6000Å : I : II : III = 1 : 3.5 : 5.0
7500Å : I : II : III = 1 : 5.0 : 10.0
11500Å : I : II : III = 1 : 1.3 : 6.5

(C) Tube No. 0-285 was pretreated similarly to 0-256 (see Report #13, pg. 3). Again, a reasonable cathode was formed, but thermionic emission was high. The same behavior has also been found on 0-256. It seems, therefore, that the presence of a thin film of Bi (or its oxide) on the cathode before the actual processing does not show any thermionic suppression effects. Such effects have clearly been shown in the use of Bi after cathode formation.

(C) Two surfaces, which had heavy $TiO_2$ coatings (80-90% coverage of Ti metal) had "broken-up" substrates and processed very poorly.

(C) Two surfaces (0-281, 0-287) were formed as space reflective cathodes (Sp RC). In both cases Al was used as mirror and a very poorly reflecting Sp R was formed.

(C) In Tube No. 0-281, no reasonable processing was possible. In Tube No. 0-287, a very poor cathode was formed. Measurements were made to establish any possible enhancement.

(C) Three areas were compared:

I : Cathode on glass only

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6000Å : I : II : III = 1 : 3.5 : 5.0

7500Å : I : II : III = 1 : 5.0 : 10.0

11500Å : I : II : III = 1 : 1.3 : 6.5

(C) It is not advisable to conclude any proven enhancement from these data, because the surface was processed for optimum sensitivity on the area III. Further data will have to be collected on better surfaces.

B) Summary of work performed during this quarterly period

1. Preparation of a space reflective cathode

(C) The difficulties in processing a satisfactory "Space Reflector" persisted.

(C) It was already observed in the last report (#14) that the aluminum opaque film always showed a "broken up" appearance after the conversion of the metallic titanium into $TiO_2$. It was definitely established that this deterioration was caused by the oxidation process, because the combination of aluminum and titanium itself was a good reflector. These "broken up" sandwiches are useless for cathode formation because their reflective character has been lost almost completely.

(C) The poor nature of the films could not be improved upon by numerous changes in the evaporation of aluminum and titanium.

(C) In order to get some workable substrates, we have returned to the use of Ag as an opaque mirror. This idea was originally discarded because it was assumed that an interaction between the Ag film and the cathode processing would take place. Although we still feel this is true, we have made several experiments with an Ag mirror.

(C) In most cases, Ag shows a better resistance to the oxidation process of titanium and several, although poor but still somewhat reflective, substrates were formed.

(C) Two surfaces, (O-281T, and O-287) which were formed on Al substrates, had low sensitivities (See A). It is expected that further experimentation will have to be made primarily on Ag mirrors.

(C) Although the problem of a space reflector has not been solved yet, we have been able to form $TiO_2$ films on glass in all different thicknesses. Here again, the thin films convert well and adhere to the glass while thicker films have a tendency to "break up" and present a "milky, whitish" appearance.

(C) It is obvious from the results that processing of cathodes on thicker films is much more difficult and unsatisfactory. So far, only one cathode (O-276T) has had some reasonable sensitivity (See Table I). Even in thinner films, cathode formation seems slightly impaired. The best sensitivity was achieved on O-244T (See Rpt. #12, Table I).

Ti ?
Ag ?

(C) In summary, we are still quite far from a solution to the problem of forming a good space reflective cathode. It also seems that additional difficulties can be expected because of a suspected different behavior of cathode formation if monitored from the vacuum side as compared to the glass or frontal incidence. Thus, it may well be that the experience gained in the formation of transmissive cathodes on $TiO_2$ substrates will not be transferrable to the formation of space reflective cathodes on the same substrate.

2. Correction of optical data

(U) The correction formulas for the determination of the optical performance of a cathode deposited on a glass surface were applied to several S-1 surfaces. We selected those surfaces which had previously been measured and reported (See Rpt. #24, Figures 31-40). Figures 7-13 of this report show the corrected results which are now representative of the cathode film proper. It is those values which will be used for the determination of the optical constants and the thickness from the available program. For the derivation of the equations used see Rpt. #12, pgs. 7-11.

3. Miscellaneous

(C) Two cathodes, (0-256, and 0-285) were formed on a glass surface, preconditioned with a thin, baked-in film of Bi. Both surfaces were reasonably good; they did not exhibit slump but thermionic emission was relatively high. The spectral response curves of interest for this quarter are given in Figures 1-6. Electrical data are given in Table I.

PART II - PROGRAM FOR THE NEXT INTERVAL (C)

(C) 1) Preparation of the combination metal reflector/$TiO_2$ layer without break-up effects.

(C) 2) Investigation of the optical and electrical properties of $TiO_2$ substrates and cathodes formed on $TiO_2$ substrates.

(C) 3) Evaluation of the computer program for determining optical constants and thickness.

(C) 4) Further investigation of possible "preconditioning" of the glass substrate.

(C) 5) Investigation of the effects of changed evaporator source-substrate distance.

PART III - MEETINGS, CONFERENCES

(U) On October 13, 1967, H. Timan from Du Mont visited ERDL, Ft. Belvoir. Progress and future developments on this contract were discussed with concerned personnel.

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TABLE I

ELECTRICAL PROPERTIES OF TUBES PROCESSED DURING THE QUARTERLY PERIOD 8/1/67 - 10/31/67

| Tube No. | Processing Date | Luminous Sensitivity in μA/L WL | 2540 | Thermionic Emission in $A/cm^2 \times 10^{12}$ | Absolute Sensitivity in mA/W 4535Å | 6015Å | 9500Å | 11500Å | Resistance in Ω/□ |
|---|---|---|---|---|---|---|---|---|---|
| 0-245 | 08/23/67 | 41 | 7.1 | 9.0 | 1.65 | 2.3 | 1.45 | .17 | $4.0 \times 10^8$ |
| 0-248 | 08/22/67 | 59 | 7.1 | 3.8 | 2.4 | 3.85 | 2.25 | .07 | $1.5 \times 10^9$ |
| 0-256 Rpt 13 | 08/24/67 | 36 | 3.6 | 25.0 | 1.5 | 2.5 | 1.5 | .04 | $2.4 \times 10^7$ |
| 0-272 | 09/13/67 | 52 | 7.1 | 17.0 | 2.7 | 3.9 | 1.55 | .22 | $7.5 \times 10^6$ |
| 0-273 | 09/14/67 | 51 | 6.5 | 81.0 | 1.95 | 3.4 | 1.7 | .16 | $1.5 \times 10^8$ |
| 0-265 | 09/15/67 | 64 | 7.8 | -- | 3.45 | 4.75 | 2.0 | .26 | -- |
| | 10/03/67 | 39 | 2.1 | Reprocessing unsuccessful. | | | | | |
| 0-266 | 09/20/67 | 53 | 5.9 | Voltage dependent. | | | | | |
| 0-267 | 09/16/67 | 65 | 7.1 | -- | -- | -- | -- | -- | -- |
| | 10/15/67 | 50 | 3.2 | Reprocessing unsuccessful. | | | | | |
| 0-276T | 10/03/67 | 21 | 3.0 | -- | -- | -- | -- | -- | -- |
| 0-285 here pa 3 | 10/25/67 | 45 | 6.8 | 90.0 | 1.6 | 2.1 | 1.4 | .11 | $7.3 \times 10^5$ |

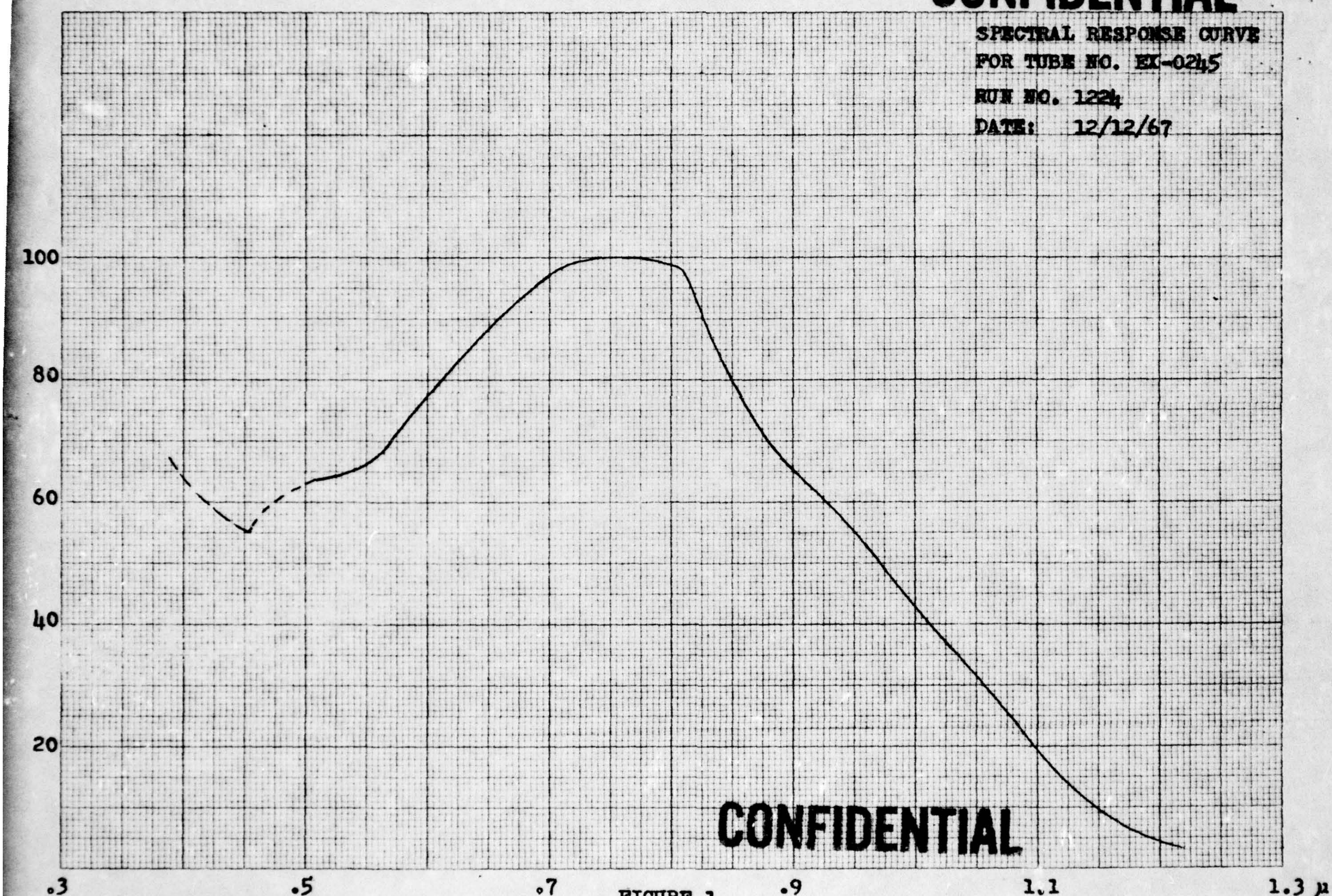
SPECTRAL RESPONSE CURVE
FOR TUBE NO. EX-0245
RUN NO. 1224
DATE: 12/12/67
100
80
60
40
20
.3
.5
.7
.9
1.1
1.3 μ



FIGURE 1

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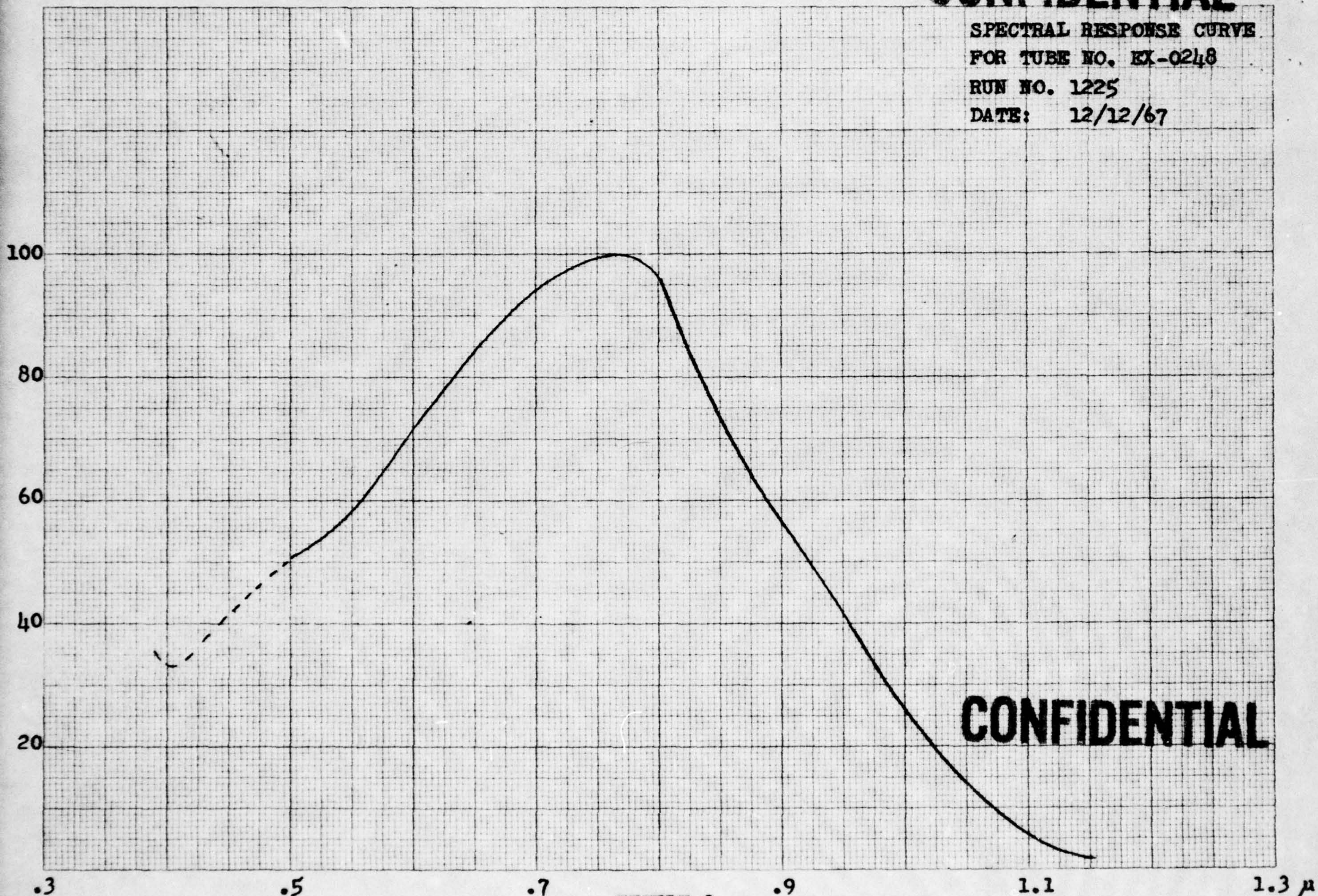


FIGURE 2

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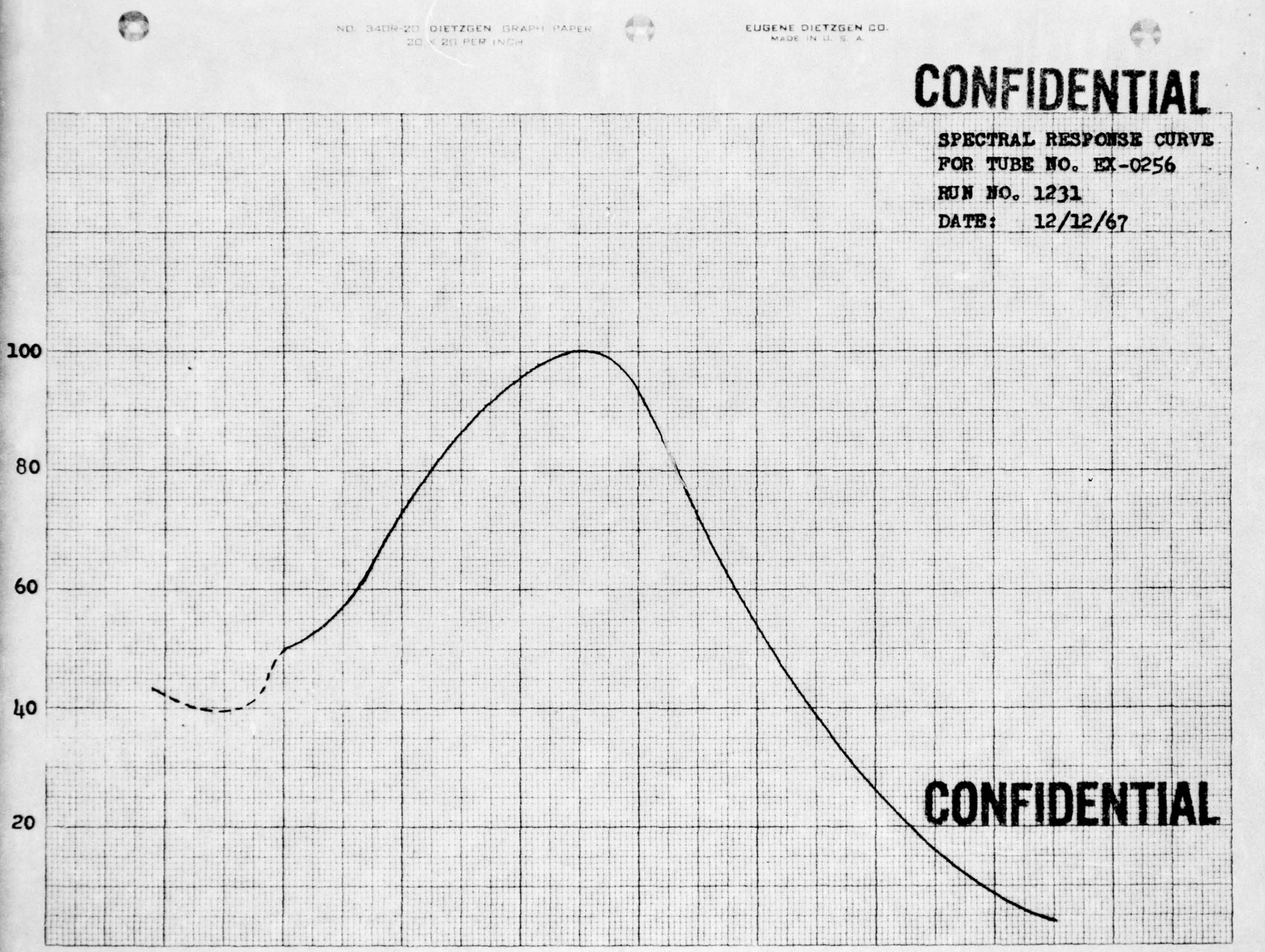
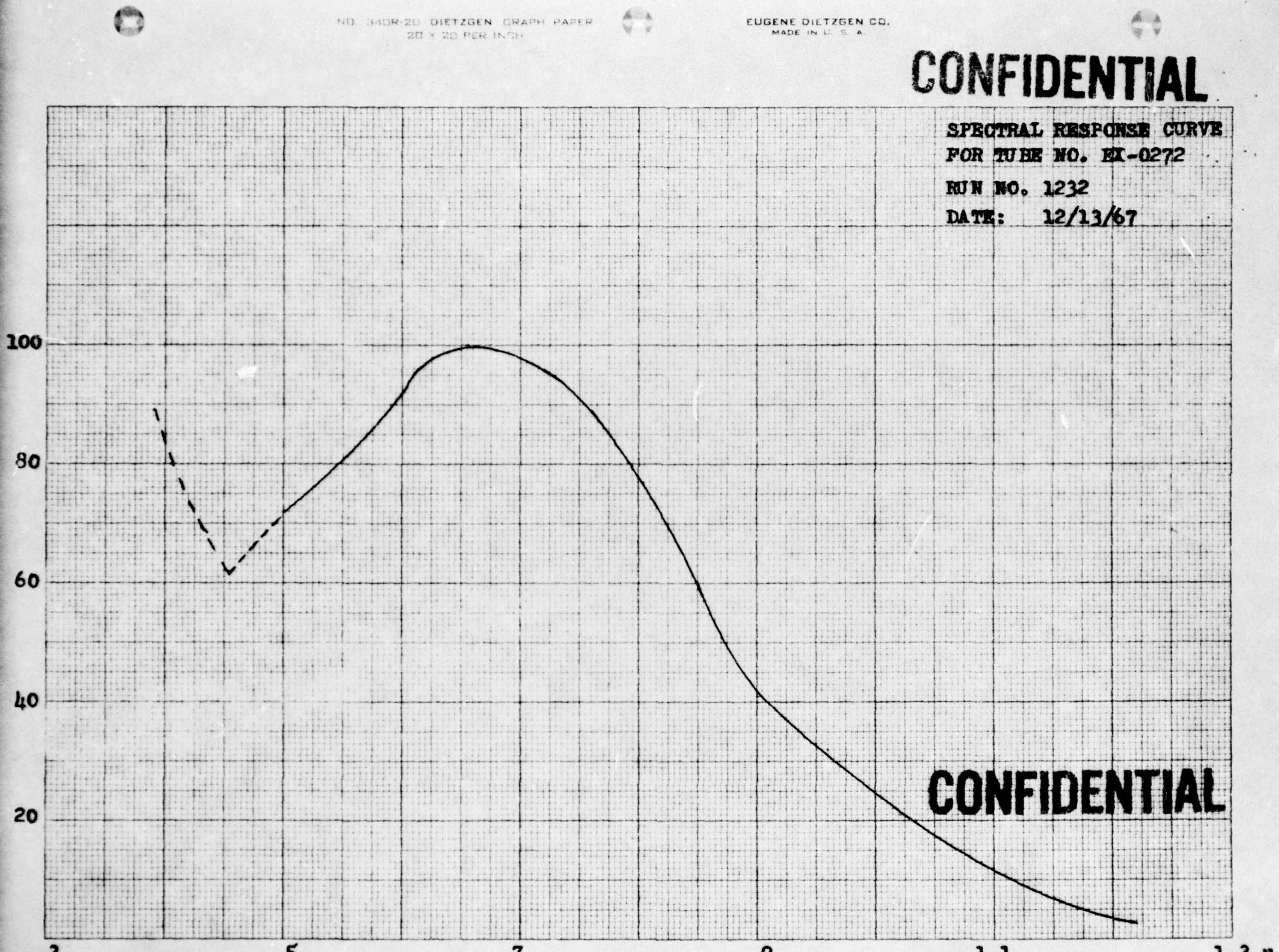

NO. 340R-20 DIETZGEN GRAPH PAPER
20 X 20 PER INCH
EUGENE DIETZGEN CO.
MADE IN U. S. A.
SPECTRAL RESPONSE CURVE
FOR TUBE NO. EX-0256
RUN NO. 1231
DATE: 12/12/67
100
80
60
40
20
.3
.5
.7
.9
1.1
1.3 μ

FIGURE 3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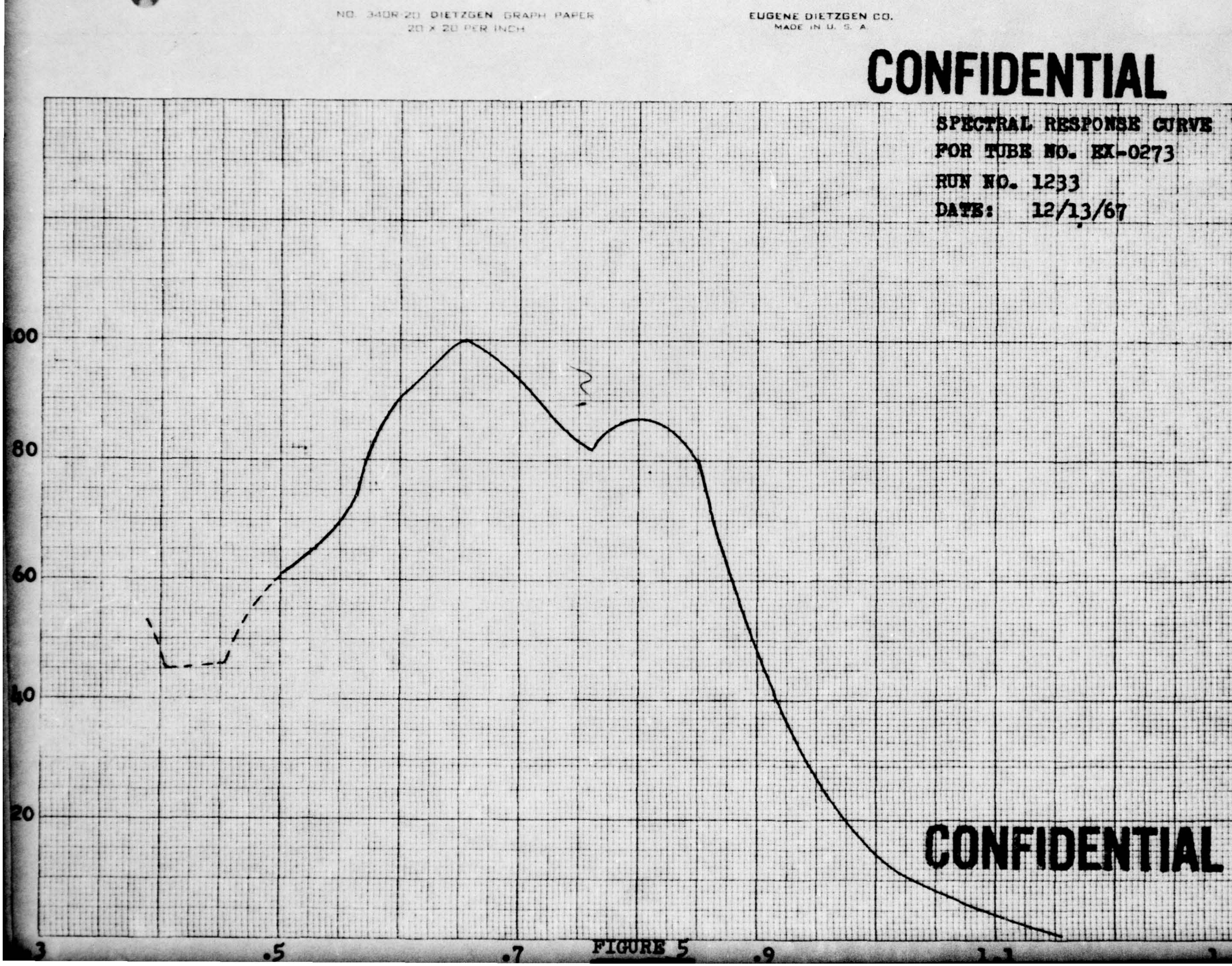
20 X 20 PER INCH
EUGENE DIETZGEN CO.
MADE IN U. S. A.
SPECTRAL RESPONSE CURVE
FOR TUBE NO. EX-0272
RUN NO. 1232
DATE: 12/13/67
100
80
60
40
20
.3
.5
.7
.9
1.1
1.3 μ

FIGURE 4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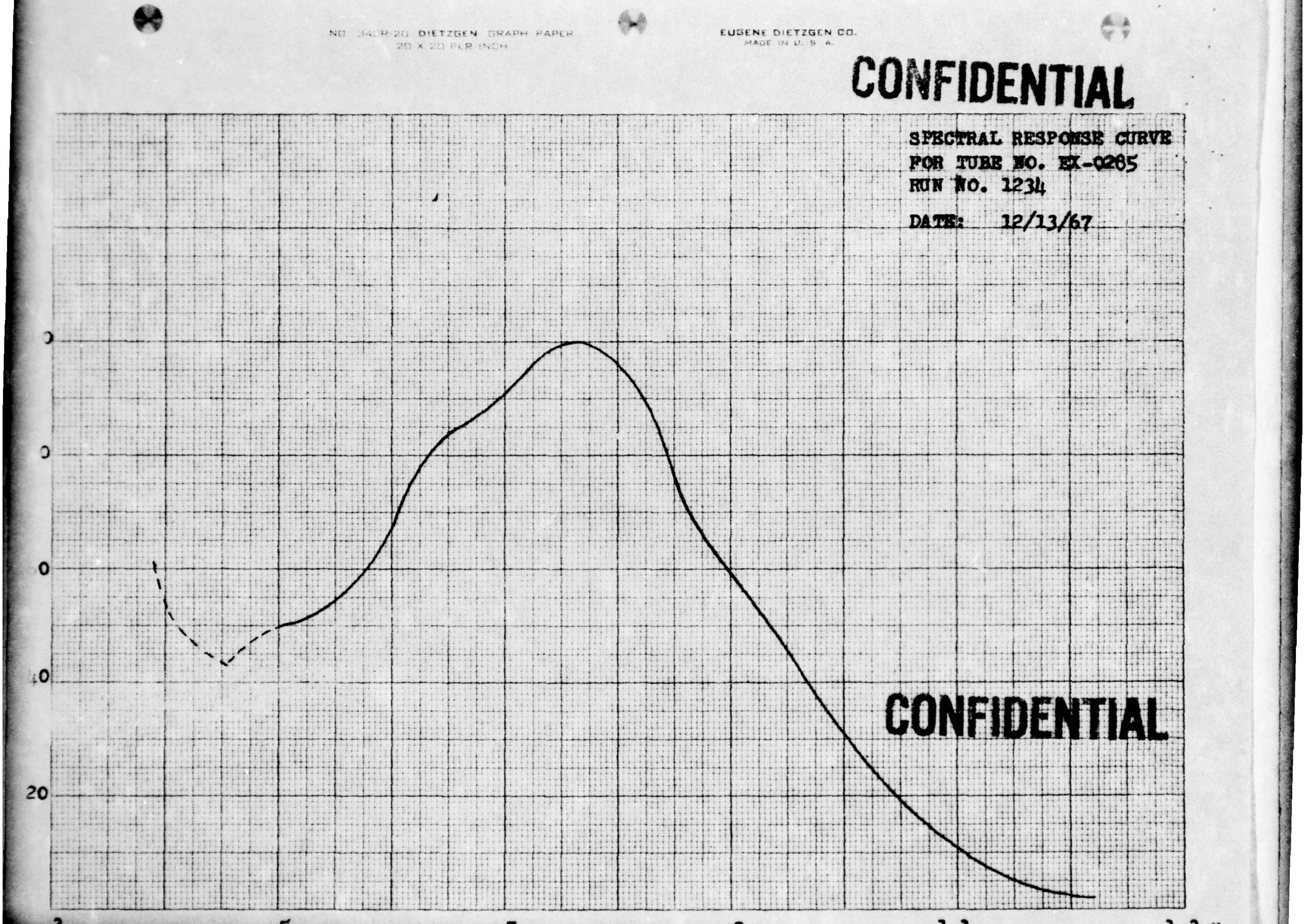
EUGENE DIETZGEN CO.
MADE IN U. S. A.
SPECTRAL RESPONSE CURVE
FOR TUBE NO. EX-0273
RUN NO. 1233
DATE: 12/13/67
100
80
60
40
20
.3
.5
.7
.9
1.1



FIGURE 5



NO. 340R-20 DIETZGEN GRAPH PAPER
20 X 20 PER INCH
EUGENE DIETZGEN CO.
MADE IN U. S. A.
CONFIDENTIAL
SPECTRAL RESPONSE CURVE
FOR TUBE NO. EX-0285
RUN NO. 1234
DATE: 12/13/67
20
.3
.5
.7
.9
1.1
1.3 μ
CONFIDENTIAL


FIGURE 6

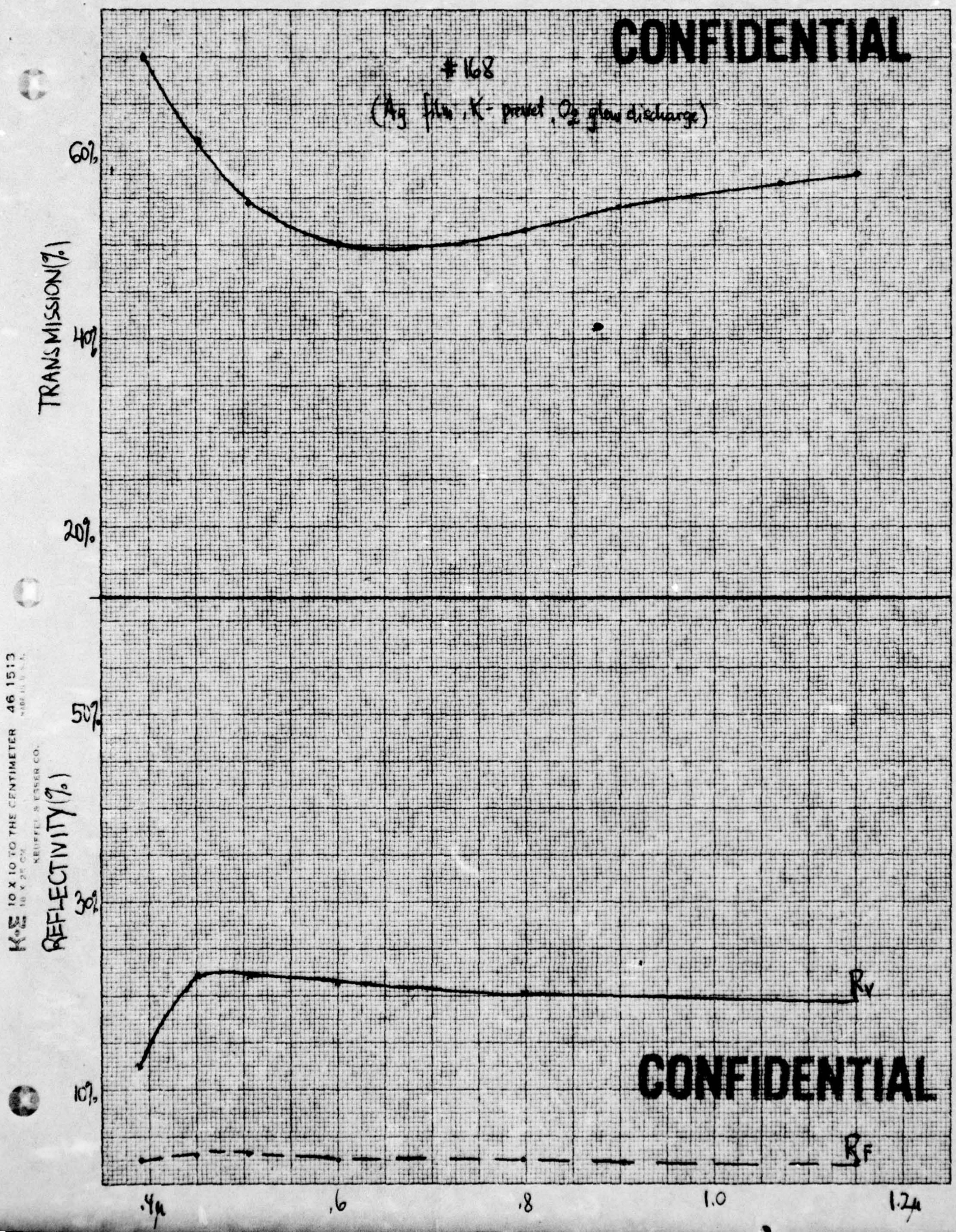
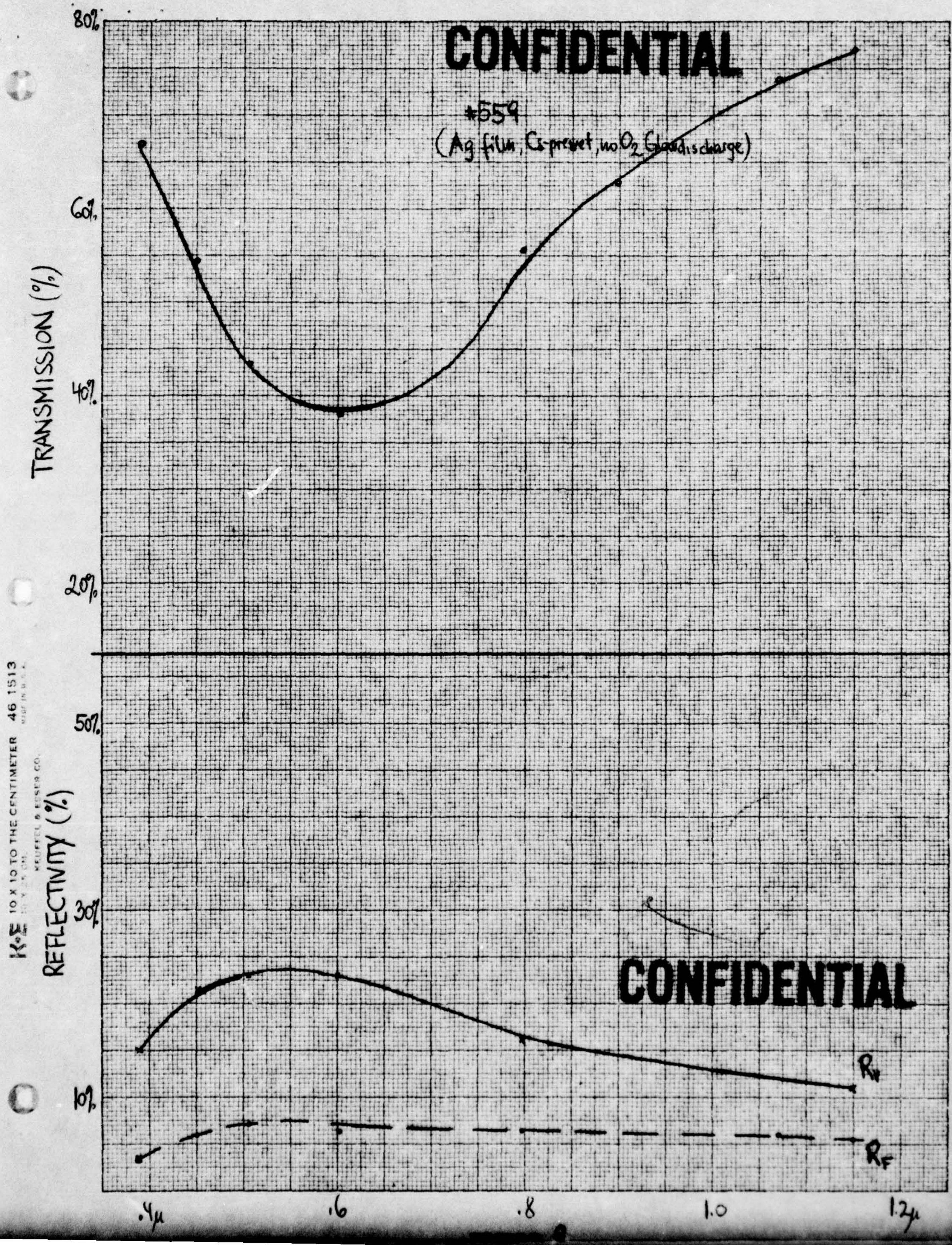

CONFIDENTIAL
#168
(Ag film, K-prevet, O2 glow discharge)
TRANSMISSION(%)
60%
40%
20%
REFLECTIVITY(%)
50%
30%
10%
Rv
RF
.4μ
.6
.8
1.0
1.2μ
CONFIDENTIAL
K&E 10 X 10 TO THE CENTIMETER 46 1513
KEUFFEL & ESSER CO.

FIGURE 7



CONFIDENTIAL
#559
(Ag film, Cs-preset, no O2 Glow discharge)
TRANSMISSION (%)
80%
60%
40%
20%
REFLECTIVITY (%)
50%
30%
10%
CONFIDENTIAL
$R_N$
$R_F$
.4μ
.6
.8
1.0
1.2μ
K+E 10 X 10 TO THE CENTIMETER 46 1513
KEUFFEL & ESSER CO.

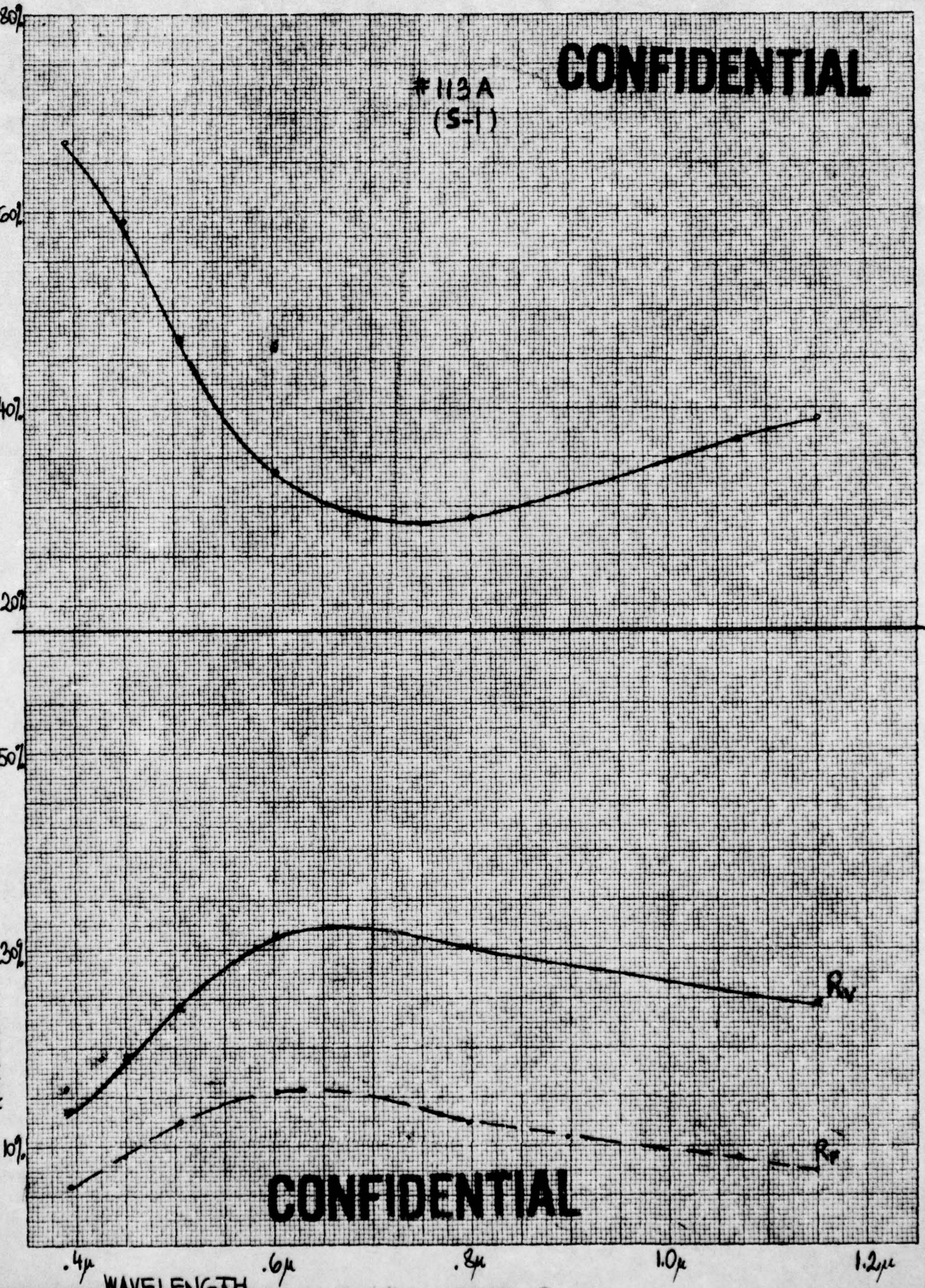



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FIGURE 9

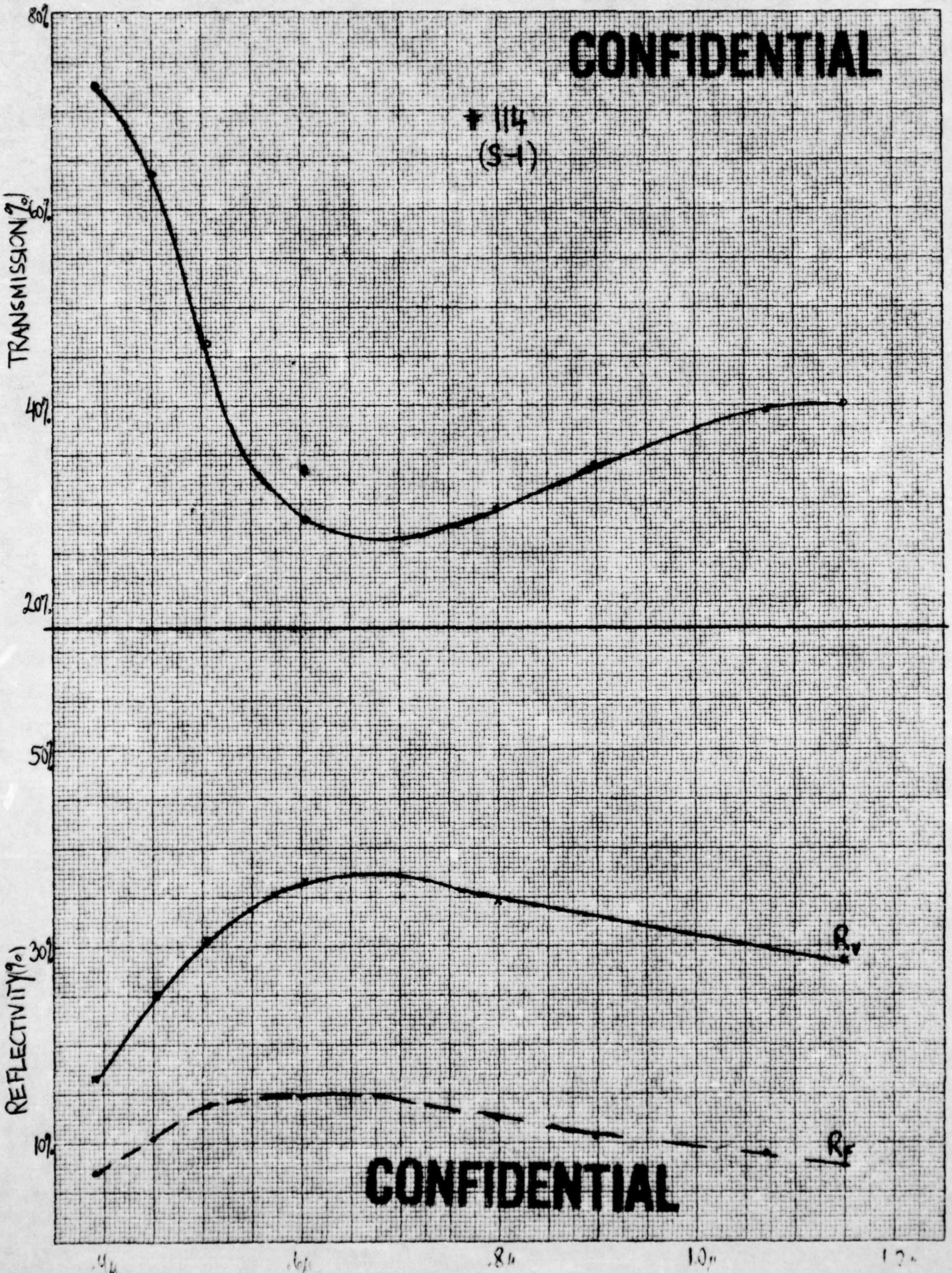
CONFIDENTIAL
# 114
(S-1)
80%
60%
40%
20%
TRANSMISSION (%)
50%
30%
10%
REFLECTIVITY (%)
R_v
R_F
CONFIDENTIAL
.4μ
.6μ
.8μ
1.0μ

FIGURE 10

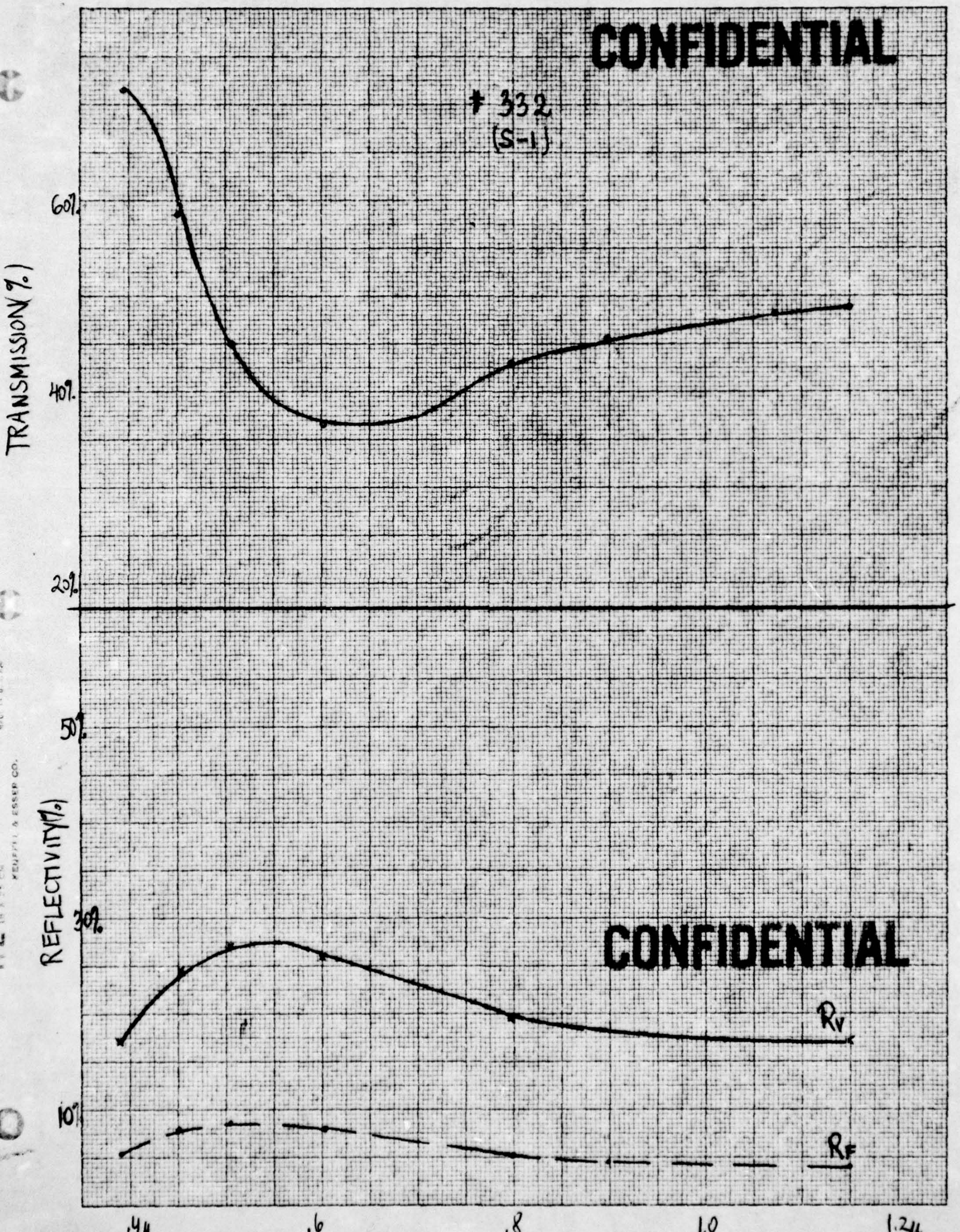
CONFIDENTIAL
# 332
(S-1)
60%
40%
20%
TRANSMISSION (%)
50%
30%
10%
REFLECTIVITY (%)
CONFIDENTIAL
$R_V$
$R_F$
.4μ
.6
.8
1.0
1.2μ

FIGURE 11

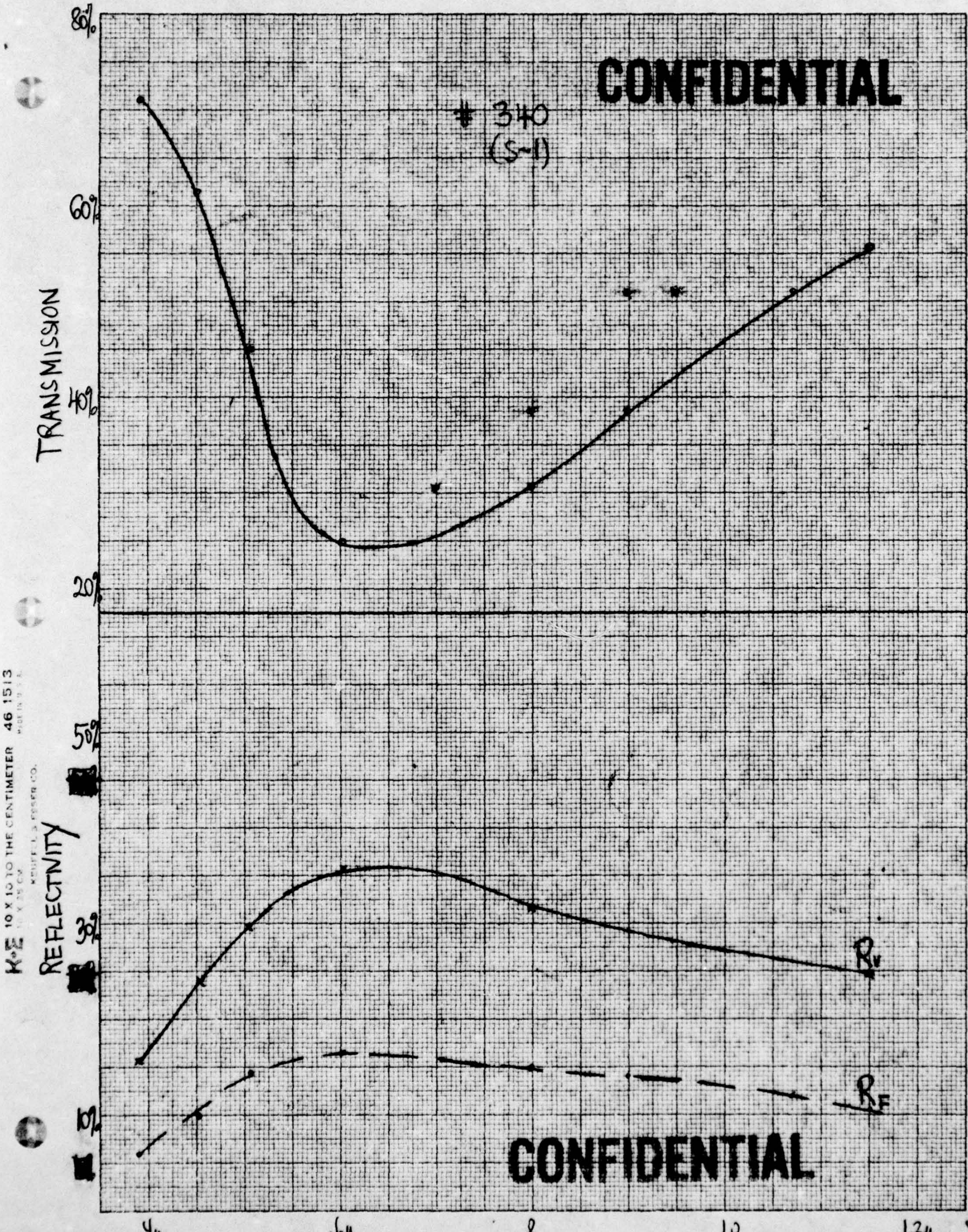
CONFIDENTIAL
# 340
(S-1)
TRANSMISSION
80%
60%
40%
20%
REFLECTIVITY
50%
30%
10%
RV
RF
CONFIDENTIAL
.4μ
.6μ
.8
1.0
1.2μ
K+E 10 X 10 TO THE CENTIMETER 46 1513

**FIGURE 12**

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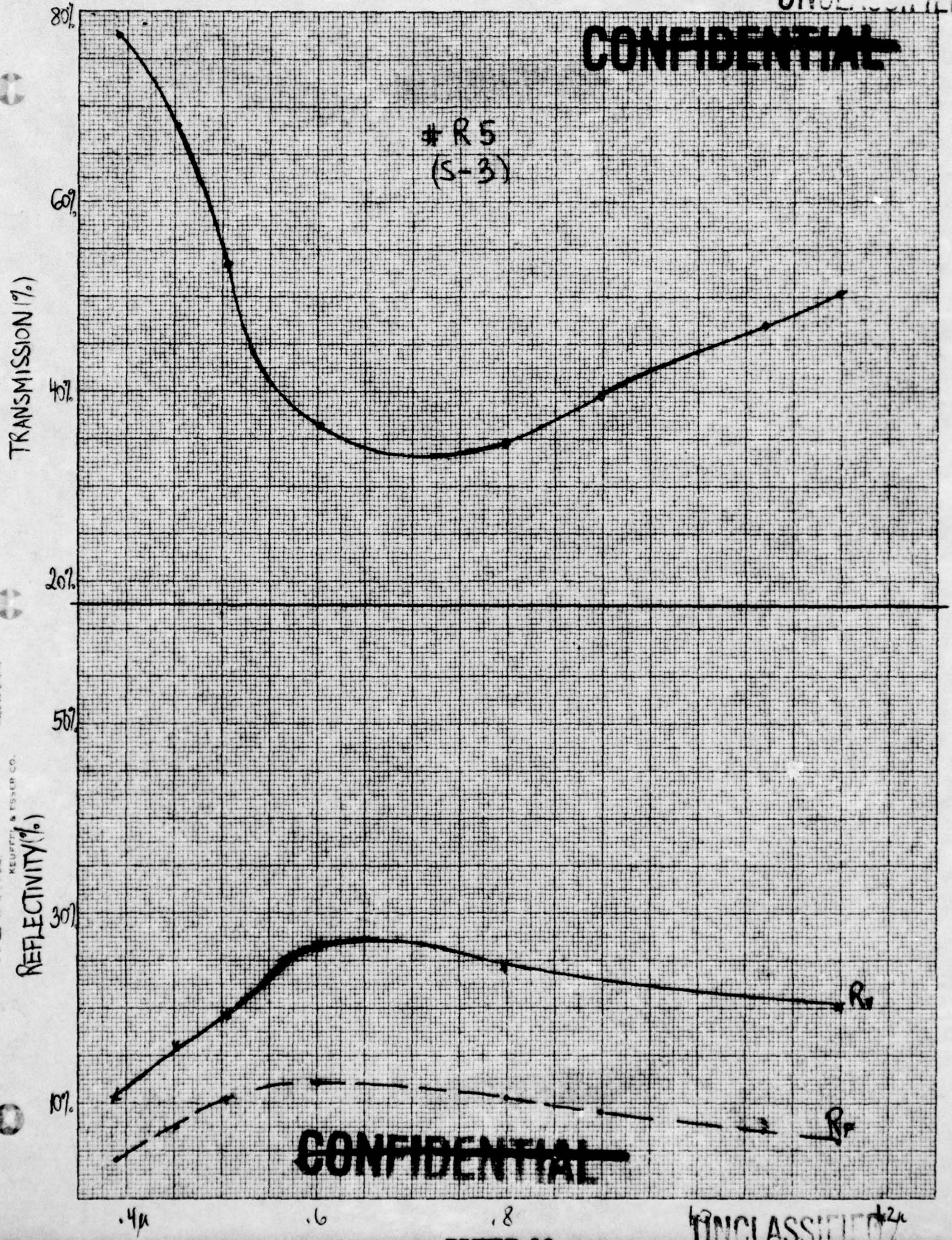


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FIGURE 13